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VALIDATION OF THE MILITARY ACUTE CONCUSSION EVALUATION (MACE) FOR IN-THEATER EVALUATION OF COMBAT-RELATED TRAUMATIC BRAIN INJURY

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14. ABSTRACT
BACKGROUND: Traumatic brain injury (TBI) has been widely considered the "signature injury" among United States military personnel involved in combat in Iraq and Afghanistan. The Military Acute Concussion Evaluation (MACE) was designed by DVBIC and civilian brain injury experts to assess the mechanism of injury, acute characteristics and cognitive deficits in military personnel with suspected MTBI in an austere environment. **PURPOSE AND SCOPE**: This study investigates the clinical and operational utility of the MACE in military operational settings. Through a systematic, retrospective review of MACE data, the specific aims of this study are: *Epidemiological:* To advance our understanding of the acute injury characteristics of MTBI in the current military operational setting (e.g., mechanisms of injury, influence of personal protective equipment (PPE), clinical indicators, severity range). *Clinical:* To determine the clinical utility of the MACE in assessing the acute signs and symptoms of MTBI, measuring the acute cognitive effects, and objectively tracking recovery; To assess the unique contribution of the MACE in clinical decision-making and modulating risk around fitness to return to duty after MTBI. **PROGRESS**: All data abstraction was completed for this retrospective data. All data has been entered into an electronic database. Statistical analysis is currently in process. No formal results or conclusions are available at the time of this abstract submission. We anticipate completion of data analysis and reporting of results within the extended study period.

15. SUBJECT TERMS
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INTRODUCTION

Traumatic brain injury (TBI) has been widely considered the “signature injury” among United States military personnel involved in combat in Iraq and Afghanistan. In previous wars such as Desert Storm, approximately 20% of military personnel treated for wounds had primary or concurrent head injuries (Carey, 1991, 1996; Leadham, Newland, & Blood, 1993). Due to several factors, however, the rate of traumatic brain injury in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) is thought to be significantly higher than any previous war (Warden, 2006). In brief, advances in protective armor (e.g., helmets and Kevlar vests) and medical triage have saved lives of military personnel that likely would have died from the same serious injuries in previous wars. Additionally, the frequency of explosive or blast attacks in Iraq and Afghanistan is significantly higher than in past military conflicts that create a new set of concerns about the risks and dynamics of closed head injury (Scott, Belanger, Vanderploeg, Massengale, & Scholten, 2006; Taber, Warden, & Hurley, 2006).

Data from the Defense and Veterans Brain Injury Center (DVBIC) headquarters at Walter Reed Army Medical Center (WRAMC) show that, among OIF and OEF veterans, 30 percent of battle injured OIF/OEF veterans were found to have traumatic brain injury, with an even greater percentage meeting TBI criteria when their mechanism of injury was blast related. As in the civilian setting, the overwhelming majority of TBI's (> 85%) in the current military conflict are categorized as MTBI based on acute injury characteristics and accepted injury definition criteria. The prevalence of MTBI in the austere environment is considered very high, a precise estimate being difficult to establish due to the fact that milder injuries may go untreated or unreported, just as in the civilian sector. Additionally, an estimated 10-20 percent of combat veterans meet the criteria for MTBI on post-deployment screening (Zoroya, 2006).

Unfortunately, MTBI presents a unique set of challenges in terms of injury detection, diagnosis, assessment and management due to the more subtle nature of injury characteristics in the absence of classic indicators (e.g., unconsciousness, amnesia, focal neurological deficit, positive neuroimaging findings). Military personnel have explicitly requested a clinical tool to assist in the acute triage of TBI that is appropriate for the frontline military operational setting.

As a result, assessment, management, and rehabilitation of deployment-related TBI has garnered increasing attention from the medical community (both military and civilian), multiple government agencies, patient advocacy groups, and the media. The Department of Defense (DoD) assembled the Defense and Veterans Brain Injury Center (DVBIC) Working Group on the Acute Management of Mild Traumatic Brain Injury (MTBI) in Military Operational Settings, which included representation from neuropsychology and generated the first Clinical Practice Guideline (CPG) in December 2006 (DVBIC, 2006). The Working Group’s CPG focused primarily on standardized algorithms for the operational assessment and management of MTBI *in-theater*, but also generated recommendations for pre-deployment baseline cognitive testing and military educational initiatives around MTBI.

The Military Acute Concussion Evaluation (MACE) (see Appendix A) was designed by DVBIC and civilian brain injury experts specifically for the purposes of assessing and documenting the mechanism of injury, acute characteristics and cognitive deficits in military personnel with suspected MTBI in an austere environment. The MACE was developed by a team of military and civilian TBI experts and first distributed for clinical use by military personnel in August 2006. The instrument is currently the only standardized and most widely used method for evaluation of acute MTBI in military operational settings. Embedded in the MACE is the Standardized Assessment of Concussion (SAC), a brief cognitive screening tool with demonstrated reliability, validity, sensitivity, and specificity in assessing the acute cognitive effects of sport-related MTBI (DVBIC, 2006; McCrea et al., 2003; McCrea, Kelly, Randolph, Cisler, & Berger, 2002).

Although the MACE and SAC have sound basis extrapolated from the sport concussion literature, *neither has been formally validated for the unique purpose of evaluating military-related MTBI, particularly in combat theater*. The current study represents the first formal investigation of the clinical and operational utility of the MACE in military operational settings.

BODY

This study is designed to focus on investigating the clinical and operational utility of the MACE in military operational settings. It is hypothesized that the MACE is a valid and reliable tool that has significant clinical utility in the acute triage of TBI in an austere environment. In keeping with the parameters of the TBI Concept Award with respect to prospective study of human subjects, a retrospective review of MACE data already collected on deployed MTBI patients since August 2006 will be executed through access to existing DoD databases. Through a systematic review of MACE data, the specific aims of this study are:

Epidemiological: To advance our understanding of the acute injury characteristics of MTBI in the current military operational setting (e.g., mechanisms of injury, influence of personal protective equipment (PPE), clinical indicators, severity range)

Specifically, the epidemiological objectives are:

- To document the frequency of specific acute injury characteristics (e.g., loss of consciousness, posttraumatic amnesia, specific symptoms) as markers of traumatic brain injury in this setting.
- To document known characteristics causing traumatic brain injury in the current setting (e.g., blast vs. blunt trauma, acceleration/deceleration, etc.)
- To document the distribution of injury severity gradient (mild, moderate, severe) in the current setting.
- To document other vital statistics relevant to traumatic brain injury (e.g., was protective helmet or other equipment worn at time of injury, etc.).
- Other objectives as identified during study

Clinical: To determine the clinical utility of the MACE in assessing the acute signs and symptoms of MTBI, measuring the acute cognitive effects, and objectively tracking recovery;
To assess the unique contribution of the MACE in clinical decision-making and modulating risk around fitness to return to duty after MTBI

Specifically, the clinical objectives are:

- To analyze MACE scores from earliest post injury assessment point to final assessment point to establish sensitivity/specificity of MACE score in detecting cognitive abnormalities after TBI, and plotting MACE score recovery curves as done in previous studies using the SAC.
- When possible, compare post-injury MACE scores to pre-injury baseline score to determine sensitivity and specificity of MACE change scores as a marker of cognitive dysfunction after TBI (and track recovery back to baseline MACE score).

- When no pre-injury baseline MACE score is available, analyze the distribution of post-injury MACE scores to help determine evidence-based cutoff scores for determining cognitive dysfunction that minimize the risk of Type I or Type II errors in clinical decision making based on MACE scores.
- To analyze MACE data and determine what symptoms are most common after TBI in this setting, both acutely and persistently
- Other objectives as identified during study

Our hypothesis tested by this study is that the MACE is a reliable, valid, sensitive and specific tool to assess traumatic brain injury that is a valuable resource to users of the tool in the current setting.

KEY RESEARCH ACCOMPLISHMENTS

During the current reporting period, the following project-related tasks have been accomplished:

1. Parameters for JTTR data capture finalized with Institute for Surgical Research (ISR).
2. Composite dataset of cases meeting parameters created and provided by ISR
3. All data abstracted from electronic databases at Walter Reed Army Medical Center.
4. De-identified data entered into centralized electronic research database.
5. Refined a detailed plan for statistical analysis of data in accordance with the study's specific aims.
6. Formal statistical data analysis initiated, in process.
7. Plan for report out of findings, peer-reviewed publications and professional presentations in process.

REPORTABLE OUTCOMES

Data analysis is in process. No reportable findings or results are available at the time of this annual report.

CONCLUSION

We anticipate significant progress ahead in completing this study according to the intended specific aims and statement of work based on the extended study period.

As it relates to military application, this study is predicted to directly address valid criticisms currently being voiced by military and civilian clinicians as to the existing gap in established validity of the Military Acute Concussion Evaluation (MACE) and Standardized Assessment of Concussion (SAC) as the main methods used to evaluate mild traumatic brain injury (MTBI) in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF).

The findings from this study are also expected to inform future prospective investigations of traumatic brain injury that utilize the MACE and similar methods, particularly for assessment of military-related MTBI. Because there is currently no widely accepted standard for objectively evaluating MTBI in either general research or clinical environments, findings from this study are predicted to have more global, ground-breaking, and translational implications for establishment of a standardized clinical instrument and research tool to evaluate MTBI in settings of mass casualty, breaches to homeland security, and other trauma settings.

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